

### REMARKS

As to claims 1, 10 and 11, the present invention is to provide a heat exchanger to a cryogenic refrigerator. To this end, the heat storing granules are of a material having a large specific heat at the now-claimed cryogenic temperature range. The granules are not in contact with other granules bonded to a sheet-like base so that heat conduction in the direction of the fluid flow can be avoided. Further, bonding of the granules, small balls, chips or fine particles on the sheet-like holding base lets the sheet be wound in multiple layers of a volute form and presents the granules from vibrating and coming into contact with other granules by a periodical velocity change of a working fluid, which repeats twice per operating cycle. If the granules vibrate and come into contact with other granules, the granules are further pulverized, causing clogging of fluid passages with pulverized particles and other troubles.

The inventions by Spocoyny (USP 5,323,842) and Sellin (USP 4,355,627) are both relative to heat exchangers for cooling hot gases of burners, which are far different from a heat exchanger for cryogenic cooling (now claimed as temperatures of 2K to 160K).

Although materials for heat exchangers disclosed in the cited references, such as Cu and high grade steel, have large values of specific heat per volume at room temperatures, they have extraordinarily small values of specific heat per volume at extremely low temperatures, in comparison with materials for heat exchangers according to the present invention, such as Nd, Gyni<sub>2</sub>, Er<sub>3</sub>Ni, etc. That is, actual values are shown as follows:

Cu: 0.0051 [J/cm<sup>3</sup>·K] at 10K  
(3.46 [J/cm<sup>3</sup>·K] at 300K)  
Fe: 0.0126 [J/cm<sup>3</sup>·K] at 10K  
(3.57 [J/cm<sup>3</sup>·K] at 300K).

Materials according to the present invention such as Nd, DyNi<sub>2</sub>, Er<sub>3</sub>Ni, etc.:

(0.3 ~ 0.8 [J/cm<sup>3</sup>·K] at 7 ~ 20K)

Therefore, the teachings of the different, hot-gas art of the references are not applicable to the invention now claimed.

In the Sellin patent, carrier pins 3 are made of a metal such as a high-grade steel and filling bodies 4 are pushed on to the carrier pins 3. Such a structure of filling bodies is completely different from that of claim 1, in which granules are bound not touching each other to avoid conduction and pulverizing losses, and the size of the filling bodies is much different from the granule sizes of present claim 1 (40-800 μm). Therefore, the combination of the patents cannot make claim 1 obvious.

As to claim 5, as mentioned above the claimed invention provides a heat exchanger in the temperature range of 2K to 160K, so that the present invention is different in object form the invention by Scarlata (USP 4,355,623) or Spokoyny which relate to heat exchanger working at a high temperature. However, in order to clarify the difference, the present claim 5 is so amended as to delete the phrase "Cu alloy, stainless steel, Fe-N alloy and". Further, in Scarlata, the size of heat storage reservoirs 15 is set to 1 to 3 inch (25,400 to 76,200μm) which is far different from 40 to 800μm of the granule size in the present invention.

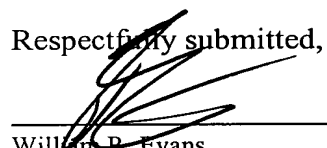
Although the Examiner points out that the applicant has previously not stated the criticality of granule size that, therefore, is simply a matter of design choice, the limitation of

the size is an essential factor of the invention. In the case of a smaller size than 40  $\mu\text{m}$ , apertures for the granules can be hardly formed on an alignment substrate, and the granules can be hardly bonded on a sheet-like holding base. In the case of a larger size than 800  $\mu\text{m}$ , the desirable surface area of the granules per diameter decreases extremely, resulting in a lower heat exchange rate and a lower adaptability to small or inexpensive apparatus.

As to claims 7, 8 and 9, the reason for defining the thickness of the sheet-like holding base is as follows. The thinner thicknesses than 10 $\mu\text{m}$  decrease the sheet strength of the base too much, while the thicker thicknesses than 100 $\mu\text{m}$  cause the size of granules on the base to be larger (about twice the thickness of the base) so that the total surface area of granules decrease.

Reconsideration and allowance are, therefore, requested.

Respectfully submitted,



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